Notice No.2

Rules for the Manufacture, Testing and Certification of Materials, July 2021

The status of this Rule set is amended as shown and is now to be read in conjunction with this and prior Notices. Any corrigenda included in the Notice are effective immediately.

Please note that corrigenda amends to paragraphs, Tables and Figures are not shown in their entirety.

Issue date: November 2021

Amendments to	Effective date	IACS/IMO implementation (if applicable)
Chapter 1, Section 5	Corrigenda	N/A
Chapter 3, Sections 3 & 10	Corrigenda	N/A
Chapter 4, Section 5	Corrigenda	N/A
Chapter 9, Section 1	Corrigenda	N/A
Chapter 13, Sections 1, 2 & 8	Corrigenda	N/A

Lloyd's Register

Chapter 1
General Requirements

■ *Section 5*
Non-destructive examination

5.1 General NDE requirements

5.1.5 It is the manufacturer's responsibility to ensure that all NDE and visual inspections are carried out in a controlled and consistent manner by certified personnel, in accordance with the approved and applicable NDE procedures, for all methods. This responsibility includes the collation ~~of,~~ and provision of accurate reports, which shall be transmitted as appropriate to LR, and in all cases be available upon request to the Surveyor.

5.2 Personnel qualifications

5.2.1 Personnel carrying out non-destructive examination and interpreting the results of non-destructive examination shall be certified to the appropriate level of a nationally recognised scheme. This requirement also extends to advanced methods, which include, but ~~is~~ are not limited to, Phased Array Ultrasonic Testing (PAUT), Time of Flight Diffraction (TOFD), and digital radiography (RT-D). Schemes such as ISO 9712, ACCP (ASNT Central Certification Program) or SNT-TC-1A fulfil this certification requirement. Other nationally recognised schemes may be acceptable, and shall be agreed with LR. Furthermore, the personnel shall be certified to the appropriate industry sector for the product type which they are examining.

5.4 Non-destructive examination testing methods

5.4.2 The surfaces under inspection are to be clean, dry and free from scale, oil, grease, dirt or paint so that there are no contaminants or entrapped material that may impede the inspection media, especially penetrant media, and are to be free of irregularities that may mask ~~of~~ or interfere with interpretation of results.

5.7 Liquid penetrant testing

5.7.1 Liquid ~~Penetrant~~ penetrant testing (PT) is to be conducted in accordance with ISO 3452-1 or a recognised National or International Standard with the extent of the PT being in accordance with the approved plans and to the satisfaction of the Surveyor.

5.10 Ultrasonic testing

5.10.4 The UT acceptance criteria for welds are based on the general requirements of ISO 11666 Quality Level C and Acceptance ~~level~~ Level 3 and apply to the examination of full penetration ferritic steel welds with thickness from 8 mm to 100 mm. The nominal frequency of transducers/probes is to be between 2 MHz and 5 MHz. Examination procedures for other types of welds, material, thicknesses above 100 mm, assessment of indications not covered in these rules and examination conditions are to be submitted for consideration by LR.

5.11 Advanced NDE methods

5.11.3 The following terms and definitions for advanced NDE will be referred to hereinafter within these Rules:

- **RT-D**: Digital ~~Radiography~~ radiography (a term for digital radiographic testing and image storage, other than film radiography. This method utilises digital detectors).

5.12 Digital radiography

Table 1.5.1 Specific requirements of a digital radiography procedure

Spatial resolution used:
Environmental and ~~Safety~~ safety issues

5.13 Phased array ultrasonic testing (PAUT)

5.13.3 All examinations utilising PAUT are to be undertaken using an approved procedure. In addition to the general procedural requirements, as specified in *Ch 1, 5.5 Non-destructive examination procedures and work instructions*, procedures for PAUT shall conform to, and specify the following requirements (where applicable):

(k) The sizing techniques include reference levels, Time Corrected Gain (TCG), Distance Gain Size (DGS) and 6 dB drop. The 6 dB drop method is only to be used for measuring the indications larger than the beam width.

Table 1.5.2 Specific requirements of a PAUT ~~Procedure~~ procedure

Requirement	Essential Variable	Nonessential Variable
Virtual aperture size (i.e.~~,~~ number of elements, effective height[1], and element width)	X	…
Focal laws for E-scan and S-scan (i.e.~~,~~ range of element numbers used, angular range used, element or angle increment change)	X	…

5.13.5 A test report is to be issued for all examinations utilising PAUT. In addition to the general reporting requirements, as specified in *Ch 1, 5.6 Non-destructive examination reports*, reports for PAUT are to ~~additionally~~ record the following information, as applicable:

(n) Details of any software used, including (but not limited to)~~;~~ scan plan set-up and component testing coverage (e.g. ray-tracing software), evaluation software, defect simulation software (where applicable).

5.14 Time of Flight Diffraction (TOFD)

5.14.2 The following requirements are to be taken into consideration when using the TOFD method:

(d) TOFD method scanning will usually involve the use of AUT or SAUT scanning techniques and equipment. Manual scanning is not usually appropriate to the TOFD method due to the nature of the equipment and scanning technique~~,~~; however, it will be specially considered if demonstrated to be effective for specific applications.

Table 1.5.3 ~~Specific Requirements of a TOFD Procedure~~ Specific requirements of a TOFD procedure

Requirement	Essential Variable	Nonessential Variable
Records, including minimum calibration data to be recorded (e.g.~~,~~ instrument settings)	…	X

5.14.5 A test report is to be issued for all examinations utilising TOFD. In addition to the general reporting requirements, as specified in *Ch 1, 5.6 Non-destructive examination reports*, reports for TOFD are to ~~additionally~~ record the following information, as applicable:

Chapter 3
Rolled Steel Plates, Strip, Sections and Bars

■ *Section 3*
Higher strength steels for ship and other structural applications

3.3 Chemical composition

Table 3.3.4 Chemical composition for brittle crack arrest steels

Grades	EH36-BCA1	EH40-BCA1 EH40-BCA2	EH47-BCA1 EH47-BCA2
Grain refining elements (Note 1 & 2)			
Aluminium (acid soluble) % (Note 3)	0,015 min	0,015 min	0,015 min
Niobium %	0,02 – 0,05	0,02 – 0,05	0,02 – 0,05
Vanadium %	0,05 – 0,10	0,05 – 0,10	0,05 – 0,10
Titanium %	0,02 max.	0,02 max.	0,02 max.
Total (Nb + V + Ti) %	0,12 max.	0,12 max.	0,12 max.

■ *Section 10*
High strength steels for welded structures

10.3 Chemical composition

Table 3.10.3 Maximum *Ceq*, *CET* and *Pcm* values

Steel yield strength level/Condition of supply	*Ceq* (%)						*CET* (%)	*Pcm* (%)
	Plates			Sections	Bars	Tubulars	all	all
	t≤50 (mm)	50<t≤100 (mm)	100<t≤250 (mm)	t≤50 (mm)	t≤250 or d≤250 (mm)	t≤65 (mm)	all	all
H69TM	0,56	N/A		N/A	N/A	~~0,36~~ N/A	~~0,30~~ 0,36	0,30

Chapter 4
Steel Castings

■ *Section 5*
Castings for propellers

5.5 Quality of castings, inspection, and ~~Non-destructive~~ non-destructive examination

5.5.4 In order to relate the degree of NDE inspection to the criticality of imperfections in propeller blades and to help reduce the risk of failure by fatigue cracking after repair, propeller blades are divided into three severity zones designated A, B and C, as given in *Ch 9, 1.8 Inspection and non-destructive examination*~~,~~ and *Figure 9.1.2 Severity zones in all propeller blades.* Proposals by the propeller designer for a modified zone area based on detailed hydrodynamic load and stress analysis may be considered by LR in conjunction with the requirements of the *Rules and Regulations for the Classification of Ships, Pt 5, Ch 7, 3.1 Minimum blade thickness 3.1.7* and relevant sections within the appropriate Rules set.

5.5.5 For all propellers, separately cast blades, and hubs, the surfaces covered by severity ~~zones~~ Zones A, B and C are to be subjected to liquid penetrant testing, or magnetic particle testing as appropriate to the material type. Testing of ~~zone~~ Zone A is to be undertaken in the presence of the Surveyor, whilst testing of ~~zone~~ Zones B and C may be witnessed by the Surveyor upon their request.

5.5.11 Advanced NDE methods, as described in *Ch 1, 5.11 Advanced NDE methods*, may be applied to steel castings for propellers, as appropriate to the material type, thickness, complexity and geometry, as a substitute for, or ~~complimentary~~ complementary to, conventional ultrasonic or radiographic testing.

Chapter 9
Copper Alloys

■ *Section 1*
Castings for propellers

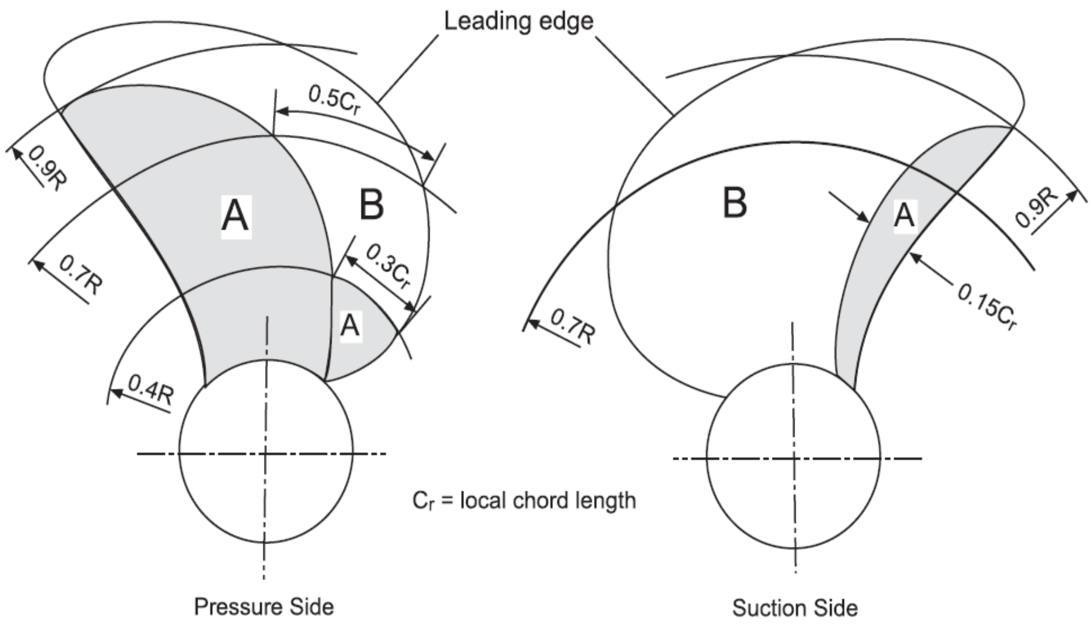
1.4 Chemical composition

Table 9.1.1 Chemical composition of propeller and propeller blade castings

Note ~~For Naval~~ for naval ships, the nickel content is to be higher than the iron content.

1.6 Test material

1.6.5 Where the manufacturer proposes test specimens to be taken from integrally cast test samples, this is to be the subject of special agreement with LR. Wherever possible, the test samples are to be located on the blades in an area lying between 0,5 to 0,6 *R*, where *R* is the radius of the propeller. The test sample material is to be removed from the casting by non-thermal procedures.



(b) Blades with propeller skew angles ~~great~~ greater than 25°

R = Propeller radius
C_r = chord length at radius *r*

Figure 9.1.2 Severity zones in all propeller blades

1.9 Rectification of defective castings

1.9.12 The following definitions apply in relation to the assessment of indications when using the liquid penetrant testing method:

(a) An indication is defined as the presence of detectable bleed-out of the penetrant liquid from the material discontinuities appearing at least 10 minutes after the developer has been applied (*see* Note 1).

(b) Relevant indication: Only indications which have any dimension greater than 1,5 mm shall be considered relevant for the categorisation of indications.

(c) Non-linear indication: an indication with a largest dimension less than three times its smallest dimension (i.e. $l < 3$ w).

(d) Linear indication: an indication with a largest dimension three or more times its smallest dimension (i.e. $l \geq 3$ w).

(e) Aligned indications:

  (i) Non-linear indications form an alignment when the distance between indications is less than 2 mm and at least three indications are aligned. An alignment of indications is considered to be a unique indication and its length is equal to the overall length of the alignment.

  (ii) Linear indications form an alignment when the distance between two indications is smaller than the length of the longest indication.

Note 1: Where there is uncertainty regarding the dimensions of the bleed-out indication size, either due to a large number of small, grouped indications, or an indication experiences excessive bleed-out, the penetrant testing process shall be repeated by strictly following the procedure.
In exceptional circumstances, whereby the indication size cannot be accurately determined, the actual discontinuity size may be further examined using visual inspection methods, and augmented with the aid of magnification instruments, to determine the actual size of the discontinuity, as visible on the surface of the material.

1.9.14 Areas which are prepared for welding are independent of their location and are always to be assessed according to Zone A. The same applies to the welded areas after being finished by machining ~~or/or~~ and/or grinding.

1.10 Weld repair procedure

1.10.4 The requirements of *Ch 12, 4.2 Requirements for copper alloys* are to be followed for the welding procedure qualification with the following exceptions and additions:

(b) Bend test may be replaced with fracture test in accordance with ISO 9017. Where fracture test is used, four fracture specimens are to be tested, two extracted from the middle and two from the end of the test weld length. The minimum length of each specimen is to be 20 mm and side notches are to be used. Fracture test results are to be assessed in accordance with the acceptance criteria specified for the non-destructive examination in *Ch 12, 2.5 Non-destructive examination (NDE)*.

1.11 Straightening

1.11.5 The heating for hot straightening is to be slow and uniform and the concentrated flames such as oxyacetylene and oxypropane should not be used. Sufficient time is to be allowed for the temperature to become uniform through the full thickness of the blade section. The temperature is to be maintained within the suggested range throughout the straightening operation. A thermocouple instrument or temperature indicating crayons ~~is~~ are to be used for measuring the temperature.

1.13 Certification of materials

1.13.2 The manufacturer is to provide the Surveyor with the following particulars for each casting:
(j) Proportion of alpha-structure for ~~Cu1~~ CU1 and ~~Cu2~~ CU2 alloys.

Chapter 13
Requirements for Welded Construction

■ *Section 1*
General welding requirements

1.11 Non-destructive examination of welds

Table 13.1.1 Cooling times prior to non-destructive examination

Type of steel	Cooling time prior to applying NDE (after all welds have reached ambient temperature and after any applicable ~~post weld~~ post-weld heat treatment)
Specified ~~Yield~~ yield strength < 420 N/mm^2 and CE ≤ 0,41	On welded structure reaching ambient temperature
420 N/mm^2 ≤ Specified ~~Yield~~ yield strength ≤ 690 N/mm^2	Not before 48 hours after completion of welding
Specified ~~Yield~~ yield strength > 690 N/mm^2	Not before 72 hours after completion of welding

■ *Section 2*
Specific requirements for ship hull structure and machinery

2.12 Non-destructive examination of steel welds

Table 13.2.5 Acceptance criteria for visual testing, magnetic particle and liquid penetrant testing

<table>
<tr><th>Surface discontinuity</th><th>Classification according to ISO 6520-1</th><th colspan="2">Acceptance ~~Criteria~~ criteria</th></tr>
<tr><td rowspan="7">Surface pore</td><td rowspan="7">2017</td><td colspan="2">Visual inspection</td></tr>
<tr><td colspan="2">Thickness (*t*)</td></tr>
<tr><td>~~*t* = >0,5 – ≤ 3,0 mm~~
0,5 mm < *t* ≤ 3,0 mm
Not permitted</td><td>*t* ~~=~~ > 3,0 mm
Butt welds: *d* = ≤ 0,2 *t* (max~~.~~ of 2,0 mm)
Fillet welds: *d* = ≤ 0,2 *a* (max~~.~~ of 2,0 mm)
See Notes 4, 5, & 6.</td></tr>
<tr><td colspan="2">Liquid penetrant inspection</td></tr>
<tr><td colspan="2">Single pore indication diameter *d* ≤ 6 mm *see* Notes 1, 2, 3 & 4.</td></tr>
<tr><td colspan="2">Magnetic particle inspection</td></tr>
<tr><td colspan="2">Single pore diameter *d* ≤ 3 mm *see* Notes 1, 3 & 4.
d = major axis of dimension</td></tr>
<tr><td rowspan="2">Undercut</td><td rowspan="2">5011 (Continuous)
5012 (Intermittent)</td><td colspan="2">Thickness (*t*)</td></tr>
<tr><td>~~*t* = >0,5 – ≤ 3,0 mm~~
0,5 mm < *t* ≤ 3,0 mm</td><td>*t* = > 3,0 mm</td></tr>
</table>

		Short imperfections only: $h \leq 0{,}1\ t$ *see* Note 7	Short imperfections only: $h \leq 0{,}1\ t$ (max 0,5 mm) *see* Note 7
		Smooth transition to parent material is required and imperfection is not to be regarded as systematic.	
Note *6*. a = ~~Throat~~ throat thickness. **Note** *7*. h = ~~Height~~ height or width of imperfection.			

2.12.5 The method to be used for the volumetric examinations of welds is the responsibility of the builder~~,~~; however, the following technical considerations shall be noted for the choice concerning the selected method:

(a) For full penetration butt welds, ~~the use of~~ advanced NDE (ANDE) methods may be used in lieu of (or complementary to) existing ultrasonic or radiographic testing methods. These methods may additionally be used on other weld configurations, with some limitations, as specified in *Table 13.2.9 Applicable methods for testing of materials and weld joints*.

(d) Where there is a requirement for enhanced NDE acceptance criteria to be applied to thick plate sections in the hatch coaming region of container ships, as per the Measure 3 requirement in *Table 8.2.1 Preventative measures to be used in design and construction for thick steel plates*, as described in *Pt 4, Ch 8, 2.3 Requirements for use of thick steel plates 2.3.10*, the UT and PAUT acceptance criteria are to be derived from the *ShipRight Procedure for the Use of Enhanced NDE in Container Ships*. ~~This~~ These derived acceptance criteria are project specific, and the acceptance criteria stated in *Table 13.2.7 Acceptance criteria for ultrasonic and Phased Array testing* ~~is~~ are not applicable.

Table 13.2.6 Acceptance criteria for radiographic testing

Discontinuity	Classification according to ISO 6520-1	Acceptance criteria
Slag inclusions, Flux inclusions, & Oxide inclusions	301, 302 & 303	h < 0,3 s (max~~.~~ 3,0 mm) ∑ l ≤ s~~,~~ (max~~.~~ 50 mm) L = 100 mm *See* Notes 1, 2, 4, 5 & 10.
Porosity & Gas pore (Single Layer)	2011 & 2012	A ≤ 1,5 % d ≤ 0,3 s (max~~.~~ 4,0 mm) L = 100 mm *See* Notes 1, 2, 3, 4, 5 & 10.
Clustered (localised) porosity	2013	$dA \leq W_p$ (max. 20 mm) L = 100 mm *See* Notes 1, 3, 5, 6, 10 & 11.
Elongated cavity & wormholes	2015 & 2016	h < 0,3 s (max. 3,0 mm) ∑ l ≤ s~~,~~ (max. 50 mm) L = 100 mm *See* Notes 1, 2, 4, 5, 8 & 10.
Shrinkage cavity (other than crater pipes)	202	Not permitted
Crater pipe	2024	Not permitted
Metallic inclusions other than copper	304	l ≤ 0,3 s~~,~~ (max. 3,0 mm) *See* Note 2
Copper inclusions	3042	Not permitted
Note *5*. s = Nominal ~~Butt~~ butt weld thickness (mm). **Note** *11*. ~~*dA + Diameter of Pore envelope*~~ d_A + Diameter of pore envelope		

Existing Table 13.2.7 has been deleted and replaced with the below:

~~Echo height~~	~~Acceptance criteria~~
Thicknesses (t) 8 mm – 15 mm	
~~Signal Amplitudes up to the Reference level (H_o)¹~~	~~Maximum length (l) of discontinuity = $l \leq t$~~
Indications resulting in signal amplitudes in excess of the reference level (H_0) are unacceptable regardless of length.	
~~Signal Amplitudes up to 50% Reference level (H_o)¹ -6dB~~	~~Indications with lengths (l) = $l > t$~~
Indications resulting in signal amplitudes above the reference level H_0 -6dB, and up to the reference level (H_0), are acceptable providing their length does not exceed the material thickness.	
Indications resulting in signal amplitudes up to H_0 -6dB are acceptable regardless of their length.	

Thicknesses (t) 15 mm – 100 mm	
~~Signal Amplitudes up to the Reference level (H_o)[1] +4dB~~	~~Maximum length (l) of discontinuity = 0,5 ≤ t~~
Indications resulting in signal amplitudes in excess of the reference level H_0 +4dB are unacceptable regardless of length.	
~~Signal Amplitudes up to the Reference level (H_o)[1] -2dB~~	~~Maximum length (l) of discontinuity = 0,5 t < l ≤t~~
Indications resulting in signal amplitudes above H_0 -2dB and up to H_0 +4dB can only have a length equal to, or less, than the half material thickness.	
~~Signal Amplitudes up to the Reference level (H_o)[1] -6dB~~	~~Indications with lengths (l) = l > t~~
Indications resulting in signal amplitudes above H_0 -6dB and up to H_0 -2dB can only have a length equal to, or less, than the material thickness.	
Indications resulting in signal amplitudes of H_0 -6dB are acceptable regardless of their length.	

Note *1*. For depiction and definition of ~~Reference level~~ reference level (H_o), *see Figure 13.2.3 Acceptance level for thicknesses 8 mm to 15 mm* and *Figure 13.2.4 Acceptance level for thicknesses 15 mm to 100 mm*.

Note *2*. For indications exceeding the ~~Evaluation Level~~ elevation level, *see Figure 13.2.3 Acceptance level for thicknesses 8 mm to 15 mm* and *Figure 13.2.4 Acceptance level for thicknesses 15 mm to 100 mm* ~~for~~ . For definition, the length of any discontinuity is to be determined using ~~Maximum Echo Amplitude method~~ maximum echo amplitude method.

Note *3*. Grouping of discontinuities based on length and separation of individually acceptable discontinuities producing amplitudes above the ~~Recording Level~~ recording level, for definition (*see Figure13.2.3 Acceptance level for thicknesses 8 mm to 15 mm* and *Figure 13.2.4 Acceptance level for thicknesses 15 mm to 100 mm)*. The length of the grouping is not to be used for further grouping.

Note *4*. For evaluation, a group of discontinuities is to be considered as a single one if:

(a) the distance along the weld axis (*dx)* between two discontinuities is less than twice the length of the longer discontinuity;
(b) the distance (*dy)* across the weld axis between two discontinuities is less than half of the thickness but not more than 10 mm; and
(c) the distance (*dz)* vertically between two discontinuities is less than half of the thickness but not more than 10 mm.

Note *5*. The combined length of the group of two discontinuities is $l_{12} = l_1 + l_2 + dx$. The combined length l_{12} and the larger maximum amplitude of the two discontinuities is then to be assessed against the applicable acceptance level.

Note *6*. The length of a single acceptable discontinuity above the ~~Recording Level~~ recording level is to be evaluated by assessing the cumulative length of all individually acceptable discontinuities above the ~~Recording Level~~ recording level, given as the sum of the lengths of both single and linearly aligned discontinuities of combined length within a given weld length. For any section of weld length ~~lw~~ $l_w = 6t$, the maximum cumulative length ~~lc~~ l_c of all individually acceptable discontinuities above the ~~Recording Level~~ recording level is not to exceed 30% of ~~lw~~ l_w.

Note *7*. Guidance on the information provided above can be referenced in ISO 11666.

Table 13.2.8 Acceptance criteria for TOFD testing[1]

Note *8*. Point-like indications and indications with height smaller than h_1 are not considered for grouping of indications. Further guidance ~~of~~ on the grouping of heights (and local heights), lengths and distance between indications can be referenced in ISO 15626.

Table 13.2.9 Applicable methods for testing of materials and weld joints

Materials and weld joints	Parent material thickness	Applicable volumetric NDE test methods (*see* Notes 1 & 2)
Ferritic and austenitic stainless steel butt welds with full penetration	~~Thickness~~ thickness < 6 mm	RT, RT-D

■ *Section 8*
Specific requirements for welded aluminium

8.4 Non-destructive examination

8.4.1 The requirements of *Ch 13, 1.11 Non-destructive examination of welds* and *Ch 13, 2.12 Non-destructive examination of steel welds* apply with the following additional provisions:

(a) For full penetration butt welds, ~~the use of~~ advanced NDE (ANDE) methods may be used in lieu of (or complementary to) existing radiographic film testing methods. These methods may additionally be used on other weld configurations, with some limitations, as specified in *Table 13.8.4 Applicable methods for the testing of aluminium weld joints.*

Table 13.8.3 Radiographic acceptance criteria for internal imperfections of aluminium

Internal discontinuity	Classification according to ISO 6520-1	Acceptance criteria (*see* Notes 1 & 2)
Clustered (localised) porosity (*see* Note 3)	2013	~~dA~~ d_A ≤ 20 mm or ~~dA~~ d_A max ≤ ~~wp~~ w_p (whichever is the lesser)
Elongated cavity and ~~W~~wormholes (*see* Note 3)	2015 2016	~~l~~ l ≤ 0,3s or 4 mm max (whichever is the lesser)
Oxide inclusion	303	~~l~~ l ≤ 0,5s or 5 mm max (whichever is the lesser)
Tungsten inclusion	3041	~~l~~ l ≤ 0,3s or 4 mm max (whichever is the lesser)
Symbols ~~*wp*~~ w_p= width of weld ~~*dA*~~ d_A= *diameter of area surrounding gas pores*		
Note *3*. Further guidance regarding determination of porosity areas and summation of acceptable areas may be referenced within the informative annexes of ISO 10675-2.		

Table 13.8.4 Applicable methods for the testing of aluminium weld joints

Materials and weld joints	Parent material thickness	Applicable volumetric NDE test methods (*see* Notes 1 & 2)
Aluminium butt welds with full penetration	Thickness < 6 mm	RT, RT-D
	~~thickness~~ Thickness ≥ 6 mm	RT, RT-D, PAUT, TOFD

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